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A comparison of two lifting assessment approaches in patients with chronic low back pain

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Abstract The Progressive Isoinertial Lifting Evaluation (PILE) and the lifting test of the Work-Well Systems Functional Capacity Evaluation (WWS) are well known as lifting performance tests. The objective of this study was to study whether the PILE and the WWS can be used interchangeably in patients with Chronic Low Back Pain (CLBP) and to explore whether psychosocial variables can explain possible differences. *Methods:* 53 Patients (32 men and 21 women) with CLBP were tested twice in a counter balanced design. Pearson Correlation Coefficient of $r > 0.75$ and non-significant differences on two-tailed t tests were considered as good comparability. *Results:* Pearson Correlation Coefficient was 0.75 ($p < 0.01$). Lifting performance on the WWS was a mean of 6.0 kg higher compared to the PILE ($p < 0.01$). The difference between the PILE and the WWS was unrelated to psychological variables. *Conclusion:* It can be concluded that the PILE and the WWS cannot be used interchangeably. Psychosocial variables cannot explain the differences between both tests.

Keywords Chronic low back pain · Validity · Lifting assessment

Introduction

Chronic low back pain (CLBP) is the number one reason for work disability in many countries [1]. Functional Capacity Evaluations (FCEs) are used to quantify specific aspects of work capacity.

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Two common FCE approaches have been described as psychophysical and kinesiophysical evaluations [2]. The psychophysical evaluation is based on the concept that human capabilities are determined by a combination of physical, perceptual, and judgmental factors that will influence the person's performance [3]. These factors are implemented in the FCE setting in such a way that the patient is in control of the situation [4] and determines his or her own acceptable maximum performance [5]. The kinesiophysical method of evaluation focuses both on the physical body and on its functional movement to determine a person's abilities and limitations [6]. It is stated that the kinesiophysical approach relies on medical objectivity and not on client subjectivity as the final determination of physical ability [3]. The test evaluates kinesiophysical principles including evaluation of muscle and joint function in relationship to strength, endurance, speed and coordination.

Because lifting has been associated with a significant percentage of work-related low-back pain episodes [7], the quantification of lifting capacity is a key issue in FCE. Two lifting tests frequently used are the psychophysical 'Progressive Isoinertial Lifting Evaluation' (PILE) presented by Mayer et al. [7] and the kinesiophysical 'waist to floor' lifting test used in the WorkWell Systems (WWS) FCE presented by Isernhagen [8]. To use these tests for clinical testing it is needed to assess their psychometric properties and it is therefore of clinical importance to know whether different approaches produce different results, because generalization of results may be possible into the clinical situation [9]. A head to head comparison between the two lifting tests, however, has never been performed.

This study was performed to study whether the PILE and the WWS lifting test can be used interchangeably. If there are differences in the outcome between the two tests, it is of concern to know why these differences exist. In CLBP, psychological factors are assumed to play an important role in the sustenance of disability [10–14]. The role of pain related fear, coping, self reported disability and symptoms of distress on test performance were explored in this study.

Methods

Subjects

53 Patients diagnosed with CLBP were included. Patients who participated in a multidisciplinary rehabilitation program and who performed an FCE were included in the study if they were between 18 to 65 years of age and were suffering from CLBP for over 3 months. Exclusion criteria were specific low back pathology, co-morbidity, pregnancy and psychopathology. Descriptive subject characteristics are presented in Table 1.

Table 1 Descriptive subject characteristics for the total group ($n = 53$) and male ($n = 32$) and female patients ($n = 21$)

Gender	Male	Female	Total
Age; years (sd)	40.2 (7.8)	36.0 (10.0)	38.5 (9.8)
height; cm (sd)	183 (6.9)	172. (7.0)	178 (8.5)
Weight; kg (sd)	88.5 (12.2)	73.0 (13.9)	82.2 (14.9)
Duration of low back pain in weeks (sd)	308 (445)	182 (269)	250 (375)
Working; yes/modified/no	10/ 9/ 7	8/ 8/ 2	18/ 17/ 9

sd = standard deviation; cm = centimeter; kg = kilogram.

Procedures

Demographics, descriptive characteristics and medical history of all patients were obtained. Prior to the lifting tests, data concerning general coping style, disability level and pain related fear was obtained by questionnaires and the patients were instructed on how to perform the PILE and the WWS. The PILE and the WWS were evaluated by separate experienced physiotherapists before rehabilitation treatment began. Mean time between the PILE and WWS was 13 days with a standard deviation of 14 days. Lifting tests were evaluated in order of convenience.

Measures

Lifting assessment

Pile

Patients performed 4 lifts from table to floor vice versa within 20 s. Weight increments of 4.5 kg for men and 2.25 kg for women were used until a criterion for maximum performance was reached. The measured outcome was the number of kg lifted. After each set of lifts, observations related to body mechanics, heart rate and a Borg-score for perceived exertion were recorded. A new series of lifting began after 20 s of rest. The test was terminated when: acceptable maximum effort (AME) was reached; lifting became unsafe; 85% of maximum age related heart rate was reached; ceiling was reached (40.5 kg); speed of lifting was not maintained [15]. Materials needed for the test include a plastic receptacle (36 × 26 × 18 cm), a table (height is 71-cm) and weights of 2.25 kg, a polar heart rate monitor and a Borg scale for exertion ranging from 0 to 10. Test-retest reliability: ICC is 0.91 in CLBP patients [15].

WWS

Patients were asked to perform 5 lifts from table to floor vice versa within 90 s. 4 to 5 weight increments were used to reach maximum lifted weight. The measured outcome was the number of kg lifted. After each lift, observations related to body mechanics and heart rate were recorded. The test was terminated when: subjects wished to do so at any point of the test; a situation became unsafe; time limit or criteria of maximum performance were reached; 85% of maximum age related heart rate was reached ($220 - \text{age} \times 85\%$). Materials used include a plastic receptacle (40 × 30 × 26 cm), a wall mounted system with adjustable shelf at 72 cm, weights of 1.0, 2.0 and 4.0 kg and a polar heart rate monitor. Test-retest reliability of patients with CLBP is: ICC is 0.78 to 0.83 (2, 16) and the interrater reliability is: ICC is 0.98 (2).

Psychological variables

Pain related fears were measured by the Dutch versions of the Tampa Scale for kinesiophobia (TSK-DV(12)) and the Fear Avoidance Beliefs Questionnaire (FABQ-DV [17]). Internal consistency of the TSK is good for patients with CLBP [12]. Test-retest reliability is unknown. The FABQ consists of two subscales, one measuring fear and avoidance behavior and one measuring fear for work-related items. Reliability and concurrent validity is moderate to good for patients with acute LBP [18]. The Dutch version of the Symptom Checklist-90 (SCL-90R) was used as a psychological status symptom inventory [19]. The SCL-90R consists of 9 subscales of which depression is one. The reliability of the Dutch version of the SCL-90R is good [19]. The

validity is sufficient to good [19]. Coping style was measured by the ‘Utrechtse Coping Lijst’ (UCL) [20]. The reliability ranges from weak to good. Predictive validity for mental health was significant [20]. Self-reported disability related to CLBP was measured by the Roland Morris Disability Questionnaire (RMDQ) [21]. The test-retest reliability in patients with CLBP is: ICC is 0.91 [22], internal consistency ranges from 0.84 to 0.93 and construct validity is good [21].

Data analysis

Both the PILE and the WWS were scored on an interval level. Maximum lifted weight (kg) was used for further analysis. To answer the question whether both tests measure the same outcome, descriptives, Pearson correlation coefficients, 95% confidence intervals of the mean difference and dependent *t* tests were calculated. The criteria for good comparison were set as for concurrent validity: Pearson correlation coefficient higher than 0.75 (23) and non-significant two-tailed *t* tests for the differences of the PILE and the WWS. To explore whether psychological measures associate to the possible difference, Pearson correlation coefficients are interpreted as follows: Correlations ranging from 0.00 to 0.25 indicate little or no relationship; from 0.25 to 0.50 indicate a fair relationship; values of 0.50 to 0.75 are moderate to good; values above 0.75 are considered good to excellent [24]. An $\alpha \leq 0.05$ was considered significant.

Results

Lifting assessment

Results of the PILE and the WWS are presented in Table 2. The mean difference between the two tests is 6.0 kilograms which means that the mean score on the PILE is approximately 75% of the WWS. Subjects who first performed the WWS did not significantly differ on person characteristics or lifting capacity from subjects who first performed the PILE (results not presented). The WWS was administered first in 31 of 53 cases.

Psychological variables

Scores from the TSK, the FABQ, the SCL-90R, the UCL, and the RMDQ are presented in Table 3. All associations were of little strength ($r < 0.25$) and statistically non-significant. None of the SCL-90R subscales correlated significantly with the test scores and are therefore not presented in the table. A high non-response rate of the psychological questionnaires was noted (Table 3). A post hoc non-response analysis revealed that non-responders did not significantly differ from responders with regards to gender, age, work status and lifting performance.

Table 2 Descriptives, differences and correlations between PILE and WWS

	<i>N</i>	Mean (kg)	sd (kg)	Min (kg)	Max (kg)	Mean difference (<i>t</i> ; df)	sd of mean differences	<i>r</i>
WWS total	53	28.3	14.0	4.0	72.0	6.0 (4.6; 52) **	9.3	0.75**
PILE total	53	22.3	10.5	4.5	40.5 ^a			

^aCeiling was reached. ** *t*-value is significant at $\alpha = 0.01$; PILE = Progressive Isoinertial Lifting Evaluation; WWS = WorkWell Systems; sd = standard deviation; *r* = Pearson correlation coefficient; df = degrees of freedom.

Table 3 Correlation of psychosocial factors with the difference of the WWS and the PILE

	<i>N</i>	Mean (sd)	WWS <i>r</i>	PILE <i>r</i>	WWS-PILE <i>r</i>
TSK	30	35.9 (7.0)	−0.08	0.02	−0.15
FABQ activities-scale	23	13.7 (5.0)	0.08	0.20	−0.10
FABQ work-scale	23	17.3 (9.7)	0.06	0.20	−0.13
SCL-90R sum	26	127.5 (23.5)	0.09	0.07	0.17
UCL	21	95.6 (5.6)	−0.03	−0.07	0.03
RMDQ	52	9.2 (5.5)	−0.15	−0.12	−0.08

No significant correlations were found; WWS: WorkWell Systems; PILE: Progressive Isoinertial Lifting Evaluation; WWS-PILE: difference between WWS and PILE; sd: standard deviation; TSK: Tampa Scale for Kinesiophobia; FABQ: Fear Avoidance Behavior Questionnaire; SCL-90R sum: sum score of the symptom check list 90-revised version; UCL: Utrechtse Coping Lijst; RMDQ: Roland Morris Disability Questionnaire.

Discussion

The purpose of this study was to compare the results of the PILE and the WWS lifting tests in a sample of patients with CLBP. The results show that the PILE and the WWS are strongly related to each other (r is 0.75) but that a significant difference of 6.0 kg in mean lifting performance exists. The criteria for comparability were not met because this difference is considered relevant. Criteria for relevance are arbitrary and criteria can in this case not be set based on internal criteria such as limits of agreement because the tests differ in procedures and test leaders. However, external criteria for relevance could be used. The relevance of the difference in lifting performance is illustrated when using The Dictionary of Occupational Titles (DOT) classification. From this study, an “average” patient with CLBP who was evaluated with the PILE (mean PILE-score is 22 kg) would be classified as suitable for medium work (occasional lifting between 9.0 kg to 22.7 kg), whereas when this same “average” patient was evaluated with the WWS, he or she would have lifted 28 kg, which would classify him as suitable for performing medium / heavy work (occasional lifting between 22.7 to 45.4 kg) [25]. To possibly explain this systematic difference an explorative study to the relationship between psychological variables and the difference between the lifting tests was performed. None of the psychological variables, however, correlated significantly with the difference between the PILE and the WWS. It appears that psychological variables cannot explain the differences between the PILE and the WWS. A weakness of this study was the high non-response of the psychological questionnaires ranging from 2% to 60%. A post hoc non-response analysis revealed that there were no significant differences between the non-responders and the responders on subject characteristics. A number of other explanations may explain the systematic difference between the performances, including procedures and purpose of the tests and the evaluator’s performance.

Differences in test procedures were: 4 lifts were used with predetermined weight increments of 2.25 or 4.5 kg in the PILE and 5 lifts were used with weights of 1.0, 2.0 and 4.0 kg in the WWS; the PILE had a ceiling at 40.5 kg where the WWS had none; in the PILE, incremental lifting proceeded in predetermined steps until acceptable maximum effort (AME) was reached. In the WWS, patients were proceeding to a maximum of lifted weight in 4 to 5 increments; The resting period in the PILE was 20 s and in the WWS a new series of lifting began when the heart rate was below 70% of the maximum age related heart rate. Ijmker et al. [9] found that equalizing the number or repetitions from 1 to 5 repetitions in an upper lifting task leads to a slightly stronger relationship and a slightly smaller difference between the test results. It is unlikely that this can explain the differences found in this study since there was only a difference of 1 lift per series. Fatigue could result in an early termination of the PILE, because the 85%

heart rate limit was reached. Heart rate calculations showed that there is a larger increase in heart rate of 8 beats per minute in the PILE ($p < 0.01$) where on average, the maximum lifted weight of the PILE is less than on the WWS. When excluding all patients who reached the weight ceiling ($N = 7$) or the 85% heart rate limit ($N = 6$), no significant changes in test results were found. Therefore, it is unlikely that different test procedures lead different test results.

Another important factor may be the difference between the kinesiophysical and the psychophysical approach. In the literature, however clear and operational definitions of both approaches cannot be found. Snook defines psychophysics as the relationship between physical stimuli that occur in the 'outside world' and the sensations they produce in the body's 'inside world' [4]. Implementation of this definition in measuring lifting capacity was done in different ways. In multiple studies, the worker is given 20–30 min to adjust his workload, usually weight or frequency of lifting, to estimate the maximum accepted workload for an 8 h work day [4, 26, 27]. Another implementation of the psychophysical approach in FCE was done by Khalil et al. [5], who introduced a new measure, namely the AME. In this form of FCE, the worker is in control and determines his or her own termination point on behalf of acceptability. In the PILE used in this study, implementation of the psychophysical approach was done according to the suggested approach by Khalil et al. [5]. The PILE used in this study was not only used as an approach to determine lifting capacity, but also as a psychophysical outcome measure. This outcome measure was generated by evaluating objective as well as subjective elements of the patients, by dividing a Borg-score and amount of weight lifted [28]. It seems that implementation of the psychophysical approach in FCE is done in different ways but overall, literature supports the concept that in the psychophysical approach performance is stopped when the worker believes AME has been reached. The kinesiophysical approach is operationally defined as evaluation of muscle and joint function (strength, endurance, speed, and coordination [3, 8]. The aim is to test a body's maximum functional abilities. In the kinesiophysical approach, the evaluator is in control and performance is stopped when biomechanical signs of maximum effort are observed. If, however, we analyze the endpoints of the subjects of both tests, 46 of 53 patients self limited their performance in the WWS and 36 of 53 patients self limited their performance in the PILE. This was an unexpected finding with regards to the theory. The differences between endpoints are small and differences in performance cannot be explained by psychological variables in this exploratory design. In practice this means that the clear kinesiophysical definition as provided by Isernhagen cannot be sustained in CLBP patients, because when a patient refuses to perform a test item or increment for any reason, the evaluator cannot determine maximum physical effort. The criterion of acceptability, as used in the psychophysical approach, may therefore not be a difference between the two approaches. These differences, described in literature as each others opposites, may thus, in practice, be non-existent with regards to endpoint determinations.

Differences between test purposes and evaluators may also lead to differences in performance. Where the WWS was used for work evaluation purposes only, the PILE was used as a measurement tool in an intake procedure for rehabilitation purposes. Instructions given to both tests were different. In the WWS it was instructed to lift as many as possible; In the PILE instructions were to lift until AME was reached. Differences between evaluators may also contribute to the differences between the test results. Interaction variability such as the physical distance between the evaluator and the patient, the way of communication and fear-avoidance level of the evaluator may have been of influence on the behavior of patients with CLBP [14, 29]. It is yet unknown and beyond the subject of this study how these differences could explain and contribute to outcome differences.

Further research is recommended to isolate possible influence of differences in test procedures, test approaches or test leader characteristics.

Conclusion

The PILE and the WWS lifting test are good related to each other but the tests cannot be used interchangeably in patients with CLBP because there is a relevant systematic difference between the tests. Psychosocial variables cannot explain the differences between the tests. Further research is recommended to study the relevance of differences between the tests.

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